JT65

JT65 – WHAT IS IT?

- A way to have a QSO using a computer
- A weak signal digital communications mode for Amateur Radio
- A Multi-Frequency Shift Keying scheme employing Forward Error Correction with 65 tones
- Created by Joe Taylor W1JT in 2003 for EME work

JT65 – Dr. Joe Taylor K1JT [1]

- Ham licence 1954
- B.A. (phys), Ph.D (ast)
- Professor of Physics
- Professor of Astronomy
- Albert Einstein Medal
- Nobel Laureate in Physics
- Addressed ITU World Radio Conference
- National Radio Astronomy Observatory
- Conducted EME at Areceibo Radio Telescope [2]

JT-65 MOTIVATIONS [5]

"Ten years of fascination with amateur radio in the 1950s and early 1960s led me to a professional life in basic research and university teaching. Over the next forty years, my research in radio astronomy taught me a great deal about extracting extremely weak signals from noise, and analyzing their content. In 2001, back on the air as an active radio amateur, I began thinking about ways to apply techniques learned and developed in the research world to the problems of weak-signal communication on our VHF and UHF bands."

- Dr. Joseph Hooton Taylor, Jr.

JT65 – WHAT IS REQUIRED?

- A Standard/Advanced Amateur Radio Licence
- An Amateur Radio Transceiver and Antenna
- A Windows® or Linux PC – not too shabby
- Free JT65 software and Free NTP software
- An Internet connection for accurate time synchronisation
- An audio and PTT interface between your transceiver and your computer

JT65 – FOR FOUNDATION? [8]

"My personal view is that there is an opportunity for amateur radio amongst technically savvy people wanting to use the capabilities of amateur radio as a tool to do something else that interests them…

If you share that view, it does seem rather counter-productive to have an entry-level licence intended to attract technically savvy people into amateur radio, which at the same time limits them to old technologies.

That's why I'm inclined to think the Foundation licence should include digital modes, but naturally that depends very much on the ACMA."

Phil Wait VK2ASD
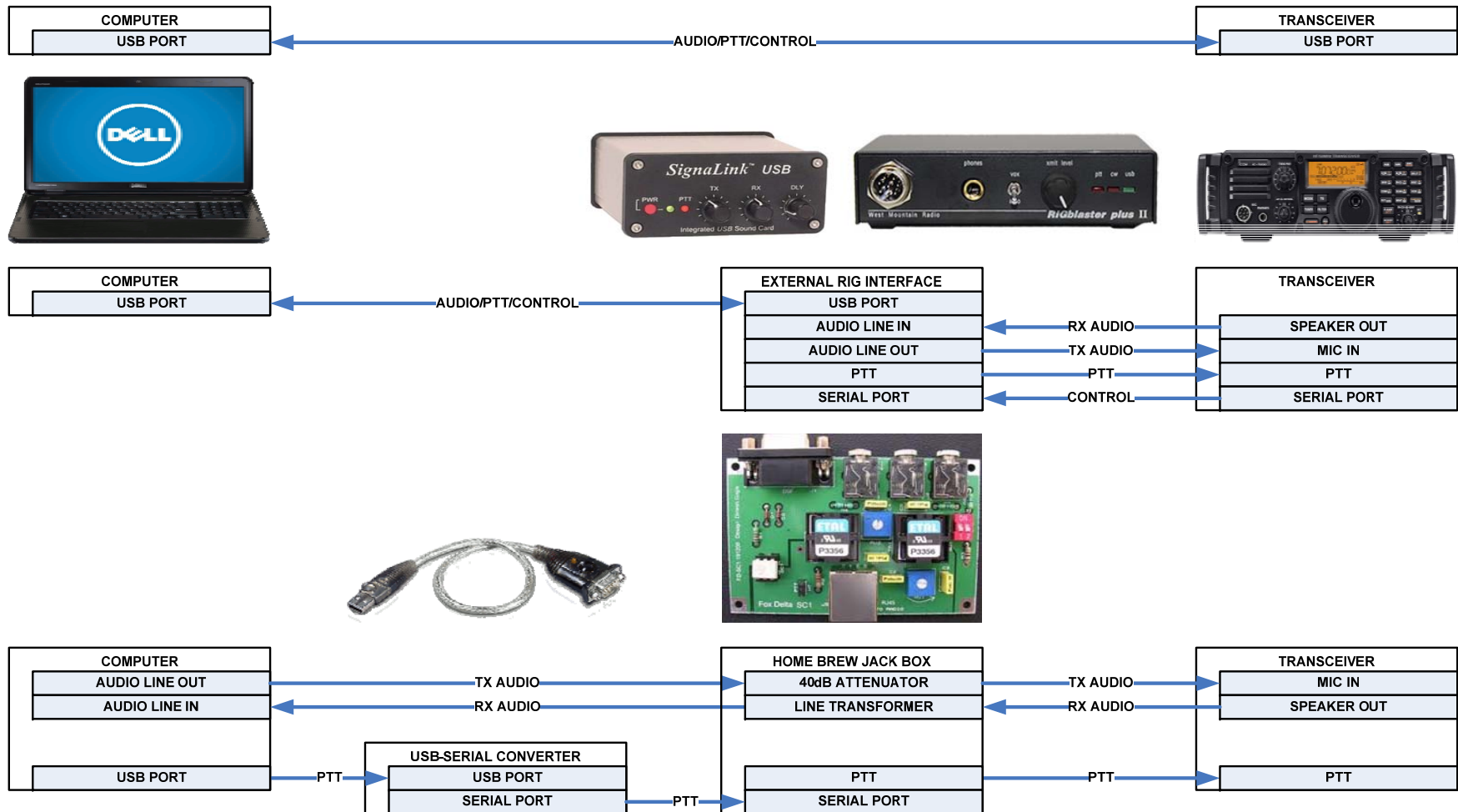
JT65 – HOW TO USE IT?

- You use a computer connected to your radio
- You select a message to wish to send to a remote station
- Your computer converts the message into audio tones
- Your computer keys your SSB transmitter automatically
- The audio tones are sent over the air and received by the remote station
- Their computer displays your call sign and location
- They send a message back to you in the same way
- Each station takes it in turns to send each other messages

YOUR COMPUTER ← AUDIO TONES → YOUR RADIO | THEIR RADIO ← AUDIO TONES → THEIR COMPUTER
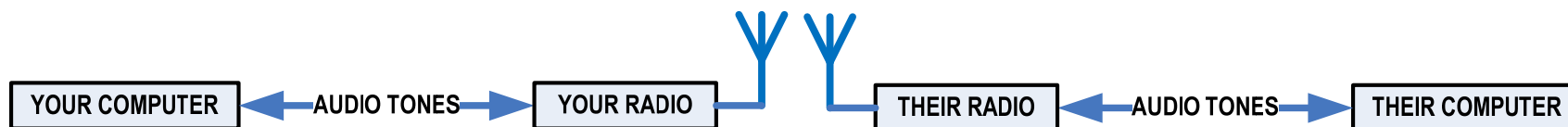
JT65 – HOW TO USE IT REALLY? [7]

- Download and install the JT65 and NTP software
- Connect the computer to the radio and to the Internet
- Tune the radio to a JT65 frequency: 1838, 3576, 7039, 7076, 14076, 10139, 18102, 21076, 24920 or 28076 kHz
- Start the JT65 software
- First time configuration: Enter your Callsign, your Grid, your Soundcard, PTT method (VOX ,CAT, DTR or RTS), CAT details
- Monitoring on-air activity first
- Select USB, adjust the power and tune up the antenna
- Test transmission and adjust audio levels in a quiet time
- Wait for a CQ message to be received. Select it to reply.
- Wait for response messages and select the next appropriate message to send. Repeat this until the QSO is finished.

JT65 – HOW TO CONNECT IT?

COMPUTER		TRANSCEIVER
USB PORT	←———— AUDIO/PTT/CONTROL ————→	USB PORT

COMPUTER		EXTERNAL RIG INTERFACE		TRANSCEIVER
USB PORT	←—— AUDIO/PTT/CONTROL ——	USB PORT		
		AUDIO LINE IN	←— RX AUDIO	SPEAKER OUT
		AUDIO LINE OUT	TX AUDIO —→	MIC IN
		PTT	PTT —→	PTT
		SERIAL PORT	←— CONTROL	SERIAL PORT

COMPUTER		HOME BREW JACK BOX		TRANSCEIVER
AUDIO LINE OUT	TX AUDIO —→	40dB ATTENUATOR	TX AUDIO —→	MIC IN
AUDIO LINE IN	←— RX AUDIO	LINE TRANSFORMER	←— RX AUDIO	SPEAKER OUT

	USB-SERIAL CONVERTER			
USB PORT	PTT —→	USB PORT		
		SERIAL PORT	PTT —→	

	HOME BREW JACK BOX		TRANSCEIVER
	PTT	PTT —→	PTT
	SERIAL PORT		

For more information see: http://www.qsl.net/wm2u/interface.html

JT65 – HOW TO CONFIGURE IT?

JT65 – HOW DOES IT WORK? [4]

- Messages containing call signs, maidenhead locators, signal reports, shorthand or text are created

- Messages are compressed into 72 bits (call signs into 28 bits and locators into 15 bits).

- Reed Solomon encoding is used to transform these 72 bits into 63, six-bit symbols

- A total of 306 bits of redundant forward error correction code is added making it more robust

- The symbols are interleaved and Gray coded (shuffled) to make them more random

- Each six-bit symbol is represented as one of 64 different audio tones.

- A 65th synchronisation tone (1270.5Hz) is also defined

- Tone frequencies for JT65A are: 1270.5 + 2.6917 (N+2): 0<=N<=63 i.e. 1270.5Hz-1445.5Hz

- The tones are constant amplitude, sinusoidal and each comprise 4096 samples at 11025 samples per second

JT65 – HOW DOES IT WORK? [4]

- The tones are sent in 126 contiguous 0.372s time intervals
- The tone transitions are phase continuous
- The synchronisation tone is inserted between the symbol tones at fixed pseudo-random positions
- The autocorrelation function of the synchronisation tones provides an accurate time sync pulse
- Each message takes exactly 46.8 seconds to send
- Each message is sent at precisely 1 second after the UTC minute rollover
- There is a 12.2 second gap in the one-minute T/R sequence

JT65 – TONES

126 sequential tones (1270-1445Hz) in 46.8 seconds
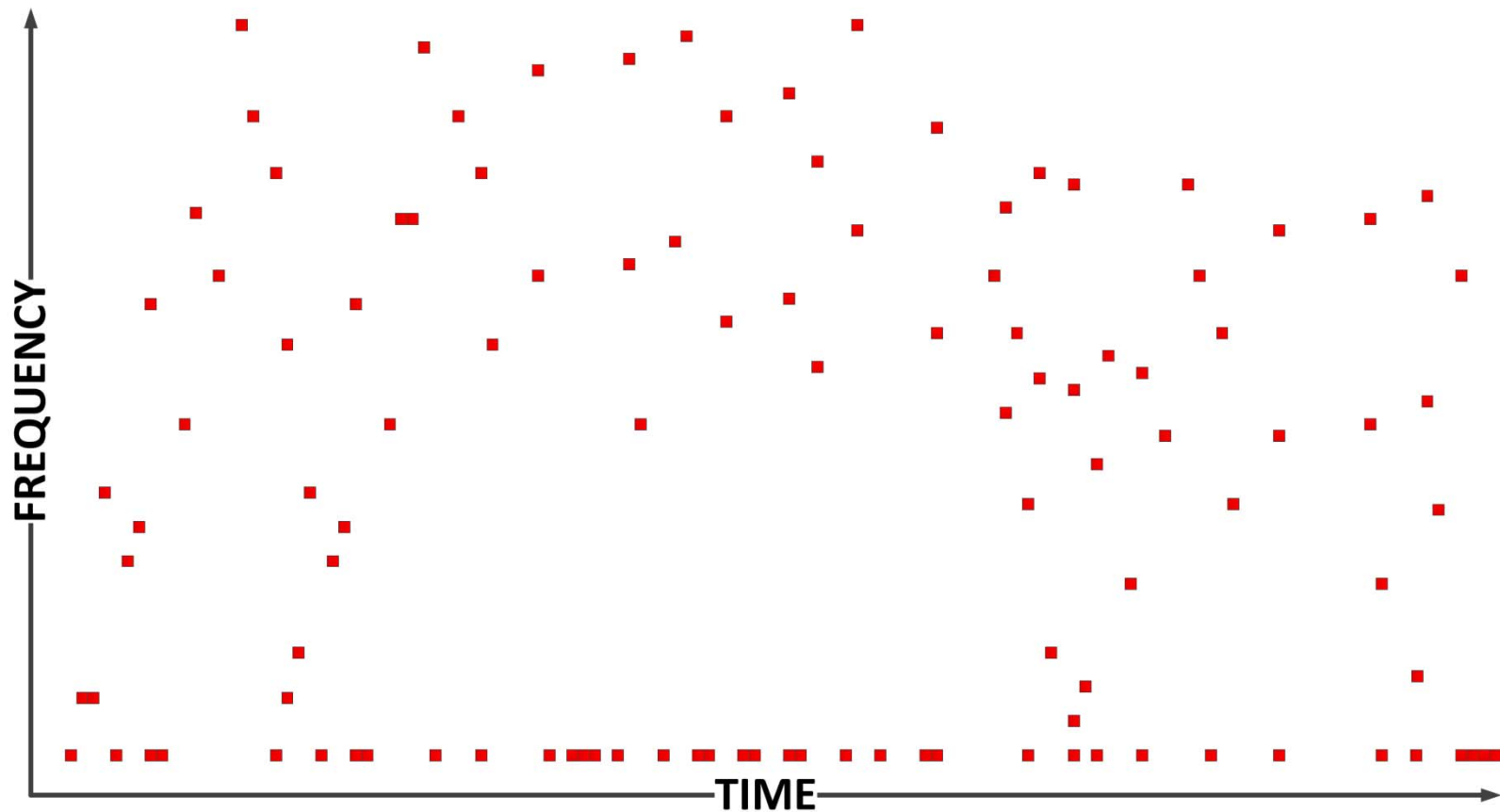
JT65 – TIME SYNCHRONIZATION[4]

"The normalised autocorrelation function of the pseudo-random synch tones provides an accurate synch pulse"

1001100011111101010001011001000111001111011011110001101010110010 1010101001000000110000000110100101101010100110010010000111111111
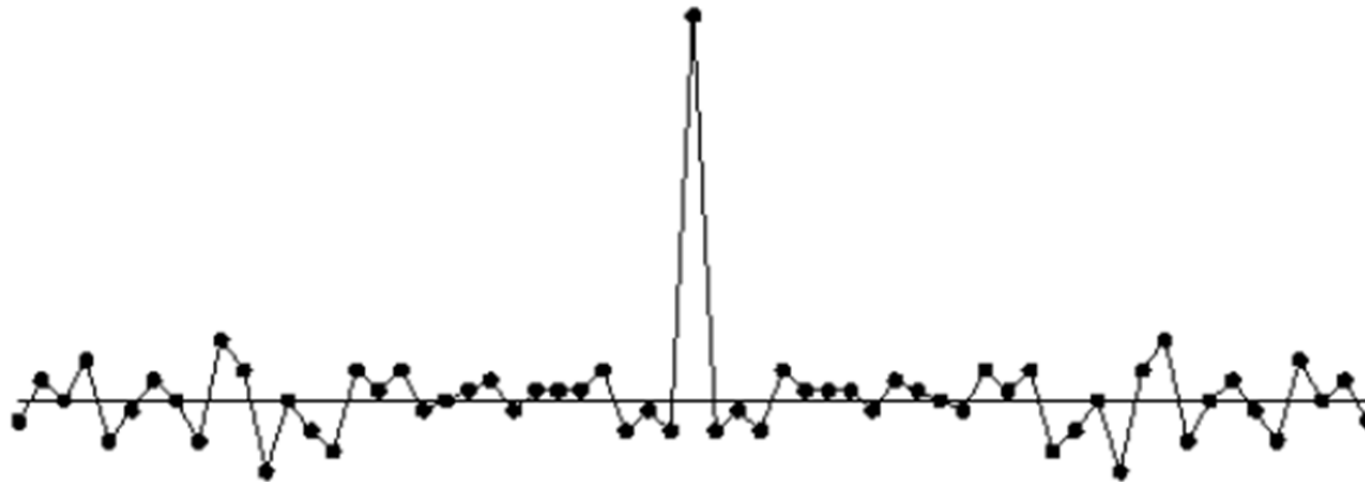
JT65 – WHAT INFO IS SENT?

A series of abbreviated text messages including:

- Each station's call sign
- Each station's Maidenhead (Grid) locator
- Each station's signal strength report
- Acknowledgement and Goodbye signals
- Up to 13 characters of free text

JT65 – WHAT ARE THE MESSAGES?

- Call message: CQ VK3ME QF22
- Reply message: VK3ME VK3YOU QF33
- Report messages: VK3YOU VK3ME R-05

    VK3ME VK3YOU R-07

- Acknowledgement message: VK3YOU VK3ME RRR
- Goodbye messages: VK3YOU VK3ME 73

    VK3ME VK3YOU 73

- Text message (13 Characters):   TU 5W 73 JOE

JT65 – WATERFALL DISPLAY
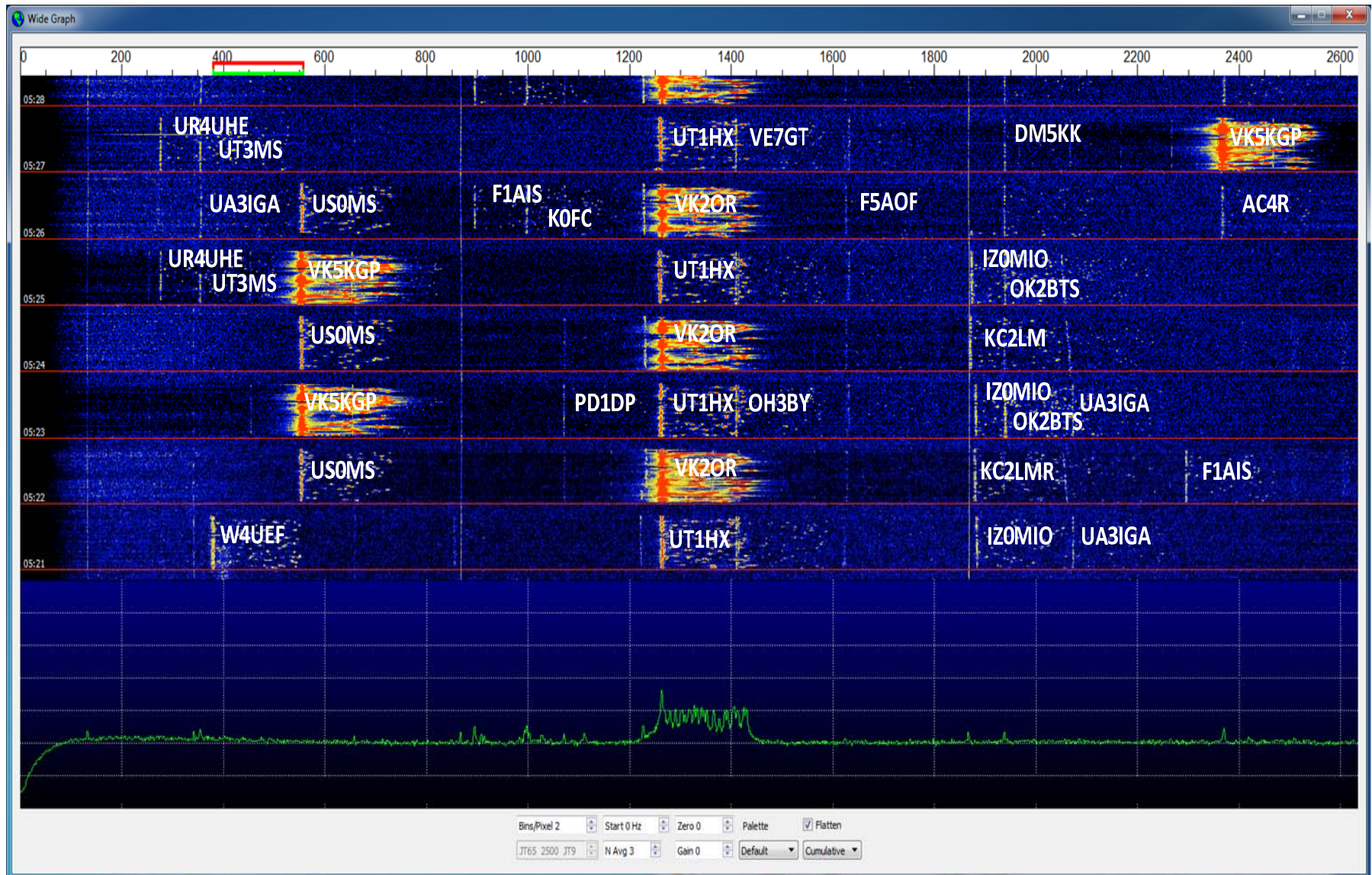
JT65 – MESSAGE HISTORY

```
UTC  dB   DT Freq  Message
----------------------------------------
0521 -16  0.1  378 # KH6OO W4UEF FM15
0521  -4  0.5 1263 # VK2OR UT1HX KO60
0521 -15 -0.1 1883 # KC2LM IZ0MIO -01
0521 -19  0.1 2073 # HA8UJ UA3IGA R-01
----------------------------------------
0522  -5  1.2  553 # CQ US0MS KN99  lUkraine
0522  -1  0.3 1263 # UT1HX VK2OR -13
0522 -14  1.2 1880 # IZ0MIO KC2LM R-11
0522 -12 -0.6 2295 # CQ F1AIS JN19  ~France
----------------------------------------
0523  -1  0.0  554 # US0MS VK5KGP PF94
0523 -21 -0.4 1070 # PY2MLS PD1DP JO32
0523  -5  0.7 1261 # VK2OR UT1HX R-11
0523 -13 -0.4 1409 # CQ OH3BY KP21  ~Finland
0523 -16 -0.1 1881 # KC2LM IZ0MIO RRR
0523 -12 -0.6 1939 # VE7GT OK2BTS JN79
0523 -19  0.1 2072 # HA8UJ UA3IGA 73
----------------------------------------
0524  -5  1.2  554 # CQ US0MS KN99  lUkraine
0524  -1  0.4 1263 # UT1HX VK2OR -13
0524 -15  1.1 1871 # IZ0MIO KC2LM 73
----------------------------------------
0525 -19  0.3  276 # CQ UR4UHE KO50 lUkraine
0525 -18 -0.0  355 # CQ UT3MS KN98  lUkraine
0525  -1  0.0  552 # US0MS VK5KGP PF94

0525  -5  0.7 1259 # VK2OR UT1HX 73
0525 -14 -0.1 1873 # KC2LM IZ0MIO
----------------------------------------
0526 -22  0.1  355 # UT3MS UA3IGA KO68
0526  -8  1.6  554 # CQ US0MS KN99  lUkraine
0526 -15 -0.7  895 # CQ F1AIS JN19  ~France
0526 -13  0.3  997 # VK2OR K0FC DM33
0526  -1  0.2 1263 # UT1HX VK2OR -13
0526 -19 -0.0 1625 # CQ F5AOF JN36 ~France
0526 -18  0.2 1938 # DM5KK VE7GT RRR
0526 -18 -0.9 2367 # CQ AC4R EM72  ~United States
----------------------------------------
0527 -19  0.4  276 # CQ UR4UHE KO50 lUkraine
0527 -20 -0.0  354 # UA3IGA UT3MS -04
0527  -6  1.1 1260 # VK2OR UT1HX R-17
0527 -15 -0.3 1409 # DM5KK VE7GT RRR
0527 -16 -0.9 1938 # VE7GT DM5KK 73
0527  -1  0.0 2367 # AC4R VK5KGP PF94
----------------------------------------
0528 -21  0.1  356 # UT3MS UA3IGA R-01
0528 -13 -0.7  895 # CQ F1AIS JN19 ~France
0528 -12  0.3  997 # VK2OR K0FC DM33
0528  -1  0.4 1263 # UT1HX VK2OR -13
0528 -19  0.1 1938 # DM5KK VE7GT 73
0528 -16 -0.9 2370 # IZ0MIO AC4R -05  73
```

JT65 – A REAL QSO

JT65 - ADVANTAGES

- Brilliant for working weak stations that you can't even hear.
- 10-15dB gain over experienced CW operators
- Only 10-15 seconds copy of a message is actually required
- It's digital: Yet another mode for contests
- It's great for DXCC: "like shooting fish in a barrel".
- QSOs with no Language Barriers: No conversational skills required!
- Efficient usage of bandwidth: 20 stations in one 3kHz HF channel?
- Fixed calling frequencies: No need to tune all around the band.
- Fascinating to watch the activity from all around the world.
- Can do EME with 150 Watts into single Yagi on 2m apparently
- Augmented by on-line DX maps and clusters

JT65 - DISADVANTAGES

- WARNING: Transmitting continuous tones may damage your transmitter !
- DANGER (for some): It requires a computer!
- Steep learning Curve: Tricky to use at first. Poorly written documentation
- Time consuming: Like watching cricket in slow motion
- Promiscuous: Get calls from anyone and anywhere: Like a VK3 instead of DX
- Can't Rag Chew: Unless you can in 13 characters or less
- Can't Run it in Unattended Mode: Have to nurse your computer the whole time
- Easy to get distracted and miss the action: Making a cup of coffee leads to on-air confusion
- Time critical: Needs accurate computer time from the Internet. Note: Windows Internet time synchronisation is insufficient. A proper NTP client like Meinberg is required.
- Frustrating: Only 12.2 seconds to make QSO decisions. Miss an opportunity and you will have to wait for two minutes or much longer.
- It's not error free. Errors can occur in decoding, rarely, but they are easy to spot.
- Subject to QRM from inconsiderate and inexperienced operators.

JT65 – OPERATING PROCEDURES

Setting up:

• Check your call sign and locator settings

• Check your time synchronisation is working

• First test your station into a dummy load. Listen for any distortion on a local receiver.

• Set power to a SAFE and friendly level: 5W-10W is fine: 25W-30W is considered high power!

• Adjust the soundcard/transmitter audio gain for zero ALC action and a clean sounding tone.

• Check your levels every time you operate as the computer volume levels are easily altered.

JT65 – OPERATING PROCEDURES

Working stations:

• Listen for at least four minutes to determine which frequencies and time slots are in use. Mentally correlate the history with the waterfall.

• Check the DTs of received signals: If they are all out, your clock may need synchronisation.

• Only respond to messages received in the last minute. The rest is history, as they say.

• Only answer CQs, at first, to gain familiarity with the band and to announce your presence.

• Don't call a station until after the last 73 or a new CQ whichever comes first.

• Call a station on a free frequency if he was not using his own frequency.

• To answer a CQ: Send reply, get report, send report, get RRR, send 73, get 73.

• A QSO is not finished until both 73s have been sent

• Stop answering a CQ immediately a station stops calling CQ or is in a QSO.

JT65 – OPERATING PROCEDURES

Calling CQ:

- Check the waterfall and history for a free frequency.

- Only call CQ on a frequency which has been unused for the last four minutes. Don't overlap anyone's frequency.

- Don't call or answer a CQ forever. Wait for two minutes to see if your frequency and time slots are in use.

- To answer a reply: Send report, get report, send RRR, get 73, send 73.

- A QSO is not finished until both 73s have been sent

- Wait for two minutes before calling CQ again to check the frequency.

- Don't use free text like "RRR 73" to minimise the number of messages

- Don't use free text at all. It is confusing.

JT65 – HINTS AND TIPS

- Check your Time Sync status
- Use AGC except for only weak signals
- Use the widest RX IF bandwidth available
- Don't use PBT, Notch Filter, Noise Blanker or Noise Reduction
- Test and tune up during the 12.2 second time gap
- Delay TX for a few seconds to see if you're doubling
- Check for doubling if you don't get a response the first time
- Call back on a clear frequency if QRM is present
- Call back on a clear frequency if the original one is still in use
- Manually select the next message, don't blindly click on each response
- Don't call a station in the middle of a QSO
- Call only after a CQ or only as soon as both 73s have been sent

JT65 - SOFTWARE

- WSJT: http://www.physics.princeton.edu/pulsar/K1JT/wsjt.html

- WSJT-X: http://www.physics.princeton.edu/pulsar/K1JT/wsjtx.html

- JT65-HF: http://sourceforge.net/projects/jt65-hf/files/setup-JT65-HF-1093.exe/download

- Multipsk: http://f6cte.free.fr/MULTIPSK.ZIP

- PSK Reporter Web Page: http://pskreporter.info/pskmap.html

JT65 - EXTRAS

- Tone Spacings: JT65B (x2), JT65C (x4)
- JT9: 9 Tones, 15.6Hz vs 177.6Hz BW, +2dB
- EME with Doppler
- RS decoding using the K-V algorithm
- JT Deep-Search decoder
- Shorthand Messages
- Setting Lock TX=RX

JT65 – RARE ERRORS

```
UTC  dB   DT  Freq   Message
-----------------------------------------
0529 -15  0.3  276 # CQ UR4UHE KO50 !Ukraine
0529 -20 -0.0  354 # UA3IGA UT3MS RRR
0529  -6  0.7 1257 # VK2OR UT1HX R-17
0529 -24 -0.0 1577 # O9KYFCS7K.YJ/
0529  -1  0.0 1623 # F5AOF VK2QN QF56
0529 -14 -0.6 1939 # VE7GT OK2BTS JN79
0529 -13 -0.1 2372 # AC4R IZ0MIO R-01
-----------------------------------------
0602 -22  0.8  545 # CQ IK1SOW JN35 ~Italy
0602  -2 -0.1  966 # WL7CG VK4ZB R-08
0602 -23 -0.3 1222 # DG5GS VK3BOB 73
0602 -22 -0.3 1422 # DG5GS VK3BOB 73
0602  -1 -0.3 1722 # DG5GS VK3BOB 73
0602 -23 -0.3 2222 # DG5GS VK3BOB 73
```

JT65 - REFERENCES

1. http://en.wikipedia.org/wiki/Joseph_Hooton_Taylor,_Jr.
2. http://physics.princeton.edu/pulsar/K1JT/Moonbounce_at_Arecibo.pdf
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10. JT65-HF Setup and Operations Guide - ARRL

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